WILDLIFE DETECTION AND ACTIVE WARNING SYSTEM

SYSTEM OPERATIONS SUMMARY

Submitted to:

Minnesota Department of Transportation
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Overview

This document presents a summary of the operational statistics and maintenance activities related to the Wildlife Detection and Active Warning System. This system is deployed in Dayton, Minnesota on County Road 121 near Elm Creek Park, which has a history of deer-vehicle crashes. The system consists of eleven detection zones (one transmit-receive detector pair per zone), along with two active warning signs and a central management control station. With the exception of the management station and one detector station, all system power is solar with rechargeable batteries.

Data collection and monitoring uses a web-based management utility that provides for data retrieval, real-time monitoring and the ability to generate alarms based on system parameters. The system automatically notified SRF staff of detector and power issues, these are noted in the "Operational Data" section of this report.

The system has proven to be robust and require minimal maintenance. When operational issues arose, staff was automatically notified, and on-site time is generally not required to rectify them. For example, several batteries were diagnosed remotely to be near failure and were replaced. Detection numbers have been higher than anticipated, primarily due to vegetation or snow interfering with detectors, but system software has minimized any negative effects on operation or durability.

The following sections detail any issues encountered during installation, the operation performance characteristics, and any maintenance or repairs needed.

Installation

Installation was performed during the fall of 2011 in conjunction with Egan Company of Brooklyn Park, MN, who provided electrical and in-ground construction services. Detector and sign assemblies were completed and tested in a shop environment prior to being moved to the project site and installed. Egan also installed the vehicle detection inductive loop detectors and the passive infrared evaluation sample detector.

Only two issues were immediately identified related to installation, although several additional minor items were uncovered during operation:

1) The warning sign for eastbound traffic was originally installed at a height such that the sign shield obscured the view of on-coming westbound traffic for drivers at the intersection of Annapolis Lane and 129th Avenue (County Road 121). The sign was raised to an appropriate height by the contractor within two days of installation and no visibility problems are now present.
2) The "Node 3" detection site did not report solar panel or battery voltages after installation, although detector inputs were reported properly and the warning system functioned as intended. This issue was subsequently corrected.

Operational Data

Detection System

The system became operational in November, 2011 and continues to function properly. Operations data has been assessed from February, 2012 to January, 2013. Although data was collected during the November to February period, a database mis-configuration caused data to be discarded on a first-in-first-out basis once a storage limit was reached. This has been corrected and the system now collects data continuously.

The primary operational data are the number of detections and the number of active warning beacon activations. Several issues affect the number of system detections, including weather, ground obstructions of the detector beam paths, and non-wildlife targets entering the detection zones. For these reasons, the number of individual detections can be very high for some detectors. However, these do not translate into the same number of system beacon activations because the system is designed to recognize erroneous detection events.

The system incorporates an error handling mechanism called "disqualification". Whenever a detector is triggered, it is said to be in a "high" state. If an object continuously breaks the beams between detectors, the detector is said to be "stuck high". If a detector remains stuck high for more than three minutes, it is disqualified from activating the beacons until it is reset through the web interface. This prevents the system from continuously activating the beacons and minimizes false activations. Notification of stuck high states is automatic if users subscribe to the alarm functions of the system via e-mail or text message. Interaction with the monitoring utilities is only necessary if an alarm is generated or if data retrieval is desired.

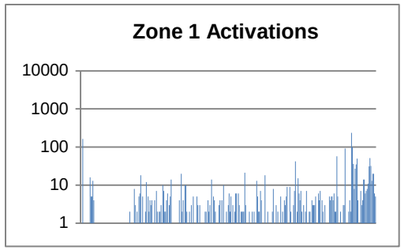
The disqualification mechanism means that a detector that is sporadically blocked by snow, grass, etc. will continue to register detections, even though it cannot activate the beacons.

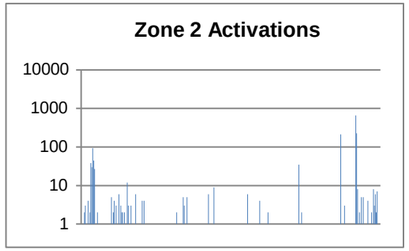
Overall, the system registered approximately 59,000 discrete detections between February 13, 2012 and January 4, 2013 or 188 per day. These detections resulted in roughly 13,000 beacon activations, or 41.5 per day. This number is greater than expected, and can be traced to several events that caused a large number of activations in short periods of time. For example, tall grasses growing between detectors were responsible for nearly 12,400 detections in eight days from June 5th to June 12th 2012. On June 12th SRF staff performed a temporary maintenance mowing that resolved the issue. An additional 8,500 detections occurred due to ground foliage in July, 2012, which was corrected by a complete mowing by Hennepin County staff. Mowing was estimated to be required twice annually (spring and fall), however the unusually hot and humid summer necessitated an additional maintenance mowing. If this had been completed in early June, the SRF interim maintenance would not have been necessary. Finally a heavy snowfall event in December, 2012 accounted for over 11,300 detections over three days.

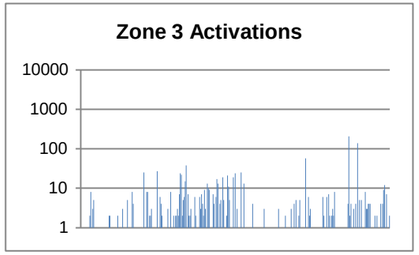
Once the foliage and weather-driven detections are factored out, there is an approximate average of 85 detections per day, with beacon activations estimated at half that number (due to detectors being activated on both sides of the roadway due to crossing). System design anticipated an average of 200 beacon activations per day.

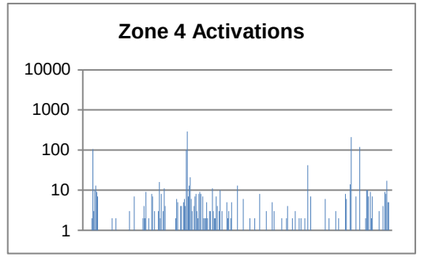
Figure 1 shows the daily total number of detections for the 12-month reporting period in each of the detection zones. Note that a logarithmic scale is used for detections. Several characteristic patterns are visible the individual charts:

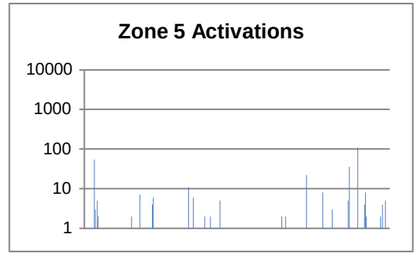
- Zones 1 and 8 display higher and more consistent detection patterns suggesting that park users following the trail shown on the diagram are being detected. The pattern also seems to indicate that more detections are made on the north side of the roadway.
- Zone 7 shows a consistent and high number of detections due to the inclusion of a private driveway for a residence that engages in apple sales.
- Zone 9 includes the parking area entry, suggesting that park users may be leaving the lot on foot as vehicles are not detected.
- Zone 10 includes a portion of the park's archery trail, and park users walking along this path typically weave across the detector beams several times as the move back to the parking walk.

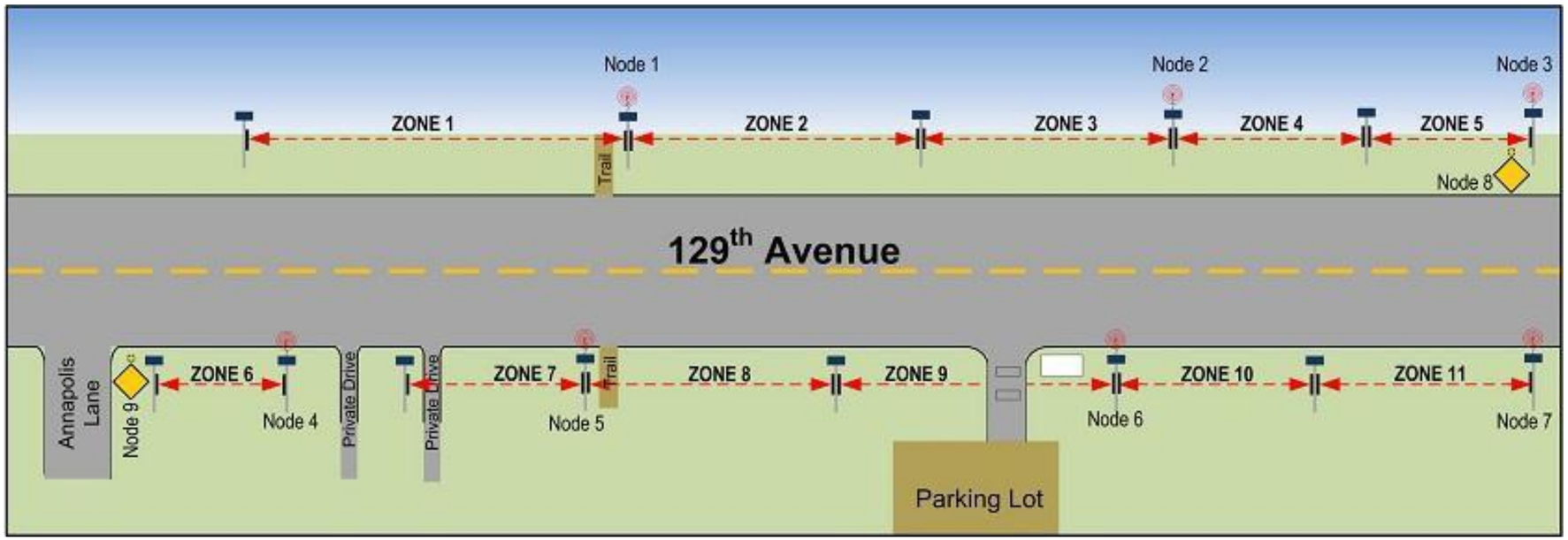


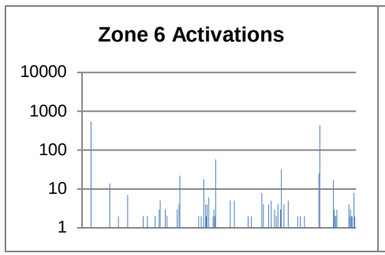


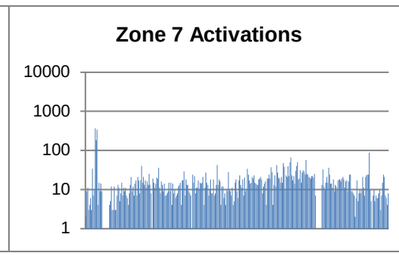


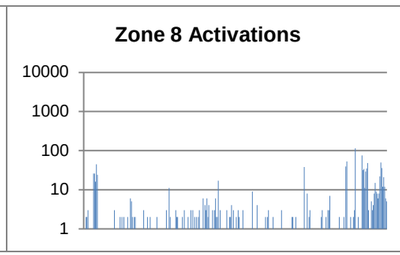


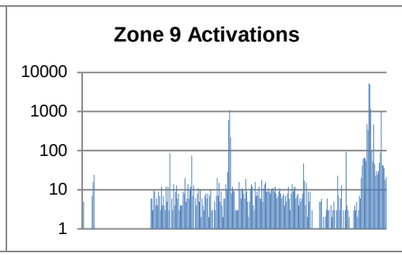


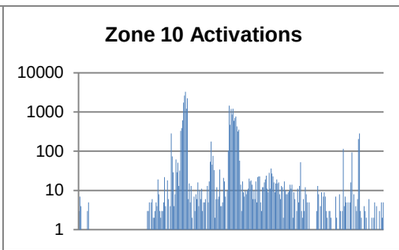


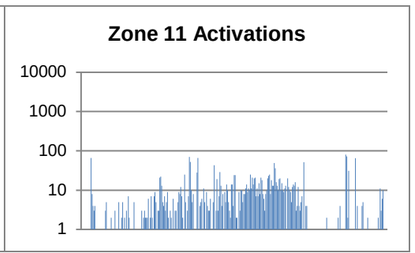












Total System Detections by Zone – February 13, 2012 to January 4, 2013

Figure 1

Dayton, MN Wildlife Detection and Active Warning System

Overall, 57 “stuck high” conditions were reported by the system. Individual stuck high disqualifications ranged from a low of six minutes and 11 seconds to a maximum of six days and 19 hours (due to plowed snow banks blocking detector beams at the parking lot entry). The frequency of disqualifications was relatively consistent, with a low of three total for Zone 2 to a maximum of eight for Zone 9, which also had plowed snow banks between detectors.

Stuck high alarms were sporadic and concentrated around weather events. On average there were approximately 1.3 alarms per week, but typically these would occur in groups within a 24 hour period around snow or freezing rain events.

Power System

The power system generated a total of 103 low voltage alarms, which indicate that the battery amp-hour capacity is getting low. However, 14 of these are due to a software upgrade to the remote management system on May 5, 2012. While this issue prevented reporting of data, it did not affect system operation. In addition one alarm was due to an installation issue at Node 3 which caused the system to incorrectly report voltages.

The largest source of low voltage alarms was Node 1, which serves detection Zones 1 and 2. This node also has an additional detector installed for evaluation purposes, which increased the power draw substantially. Low voltage indications were highly correlated to weather events in the fall and early winter, which are characterized by long overcast periods and low sun angles.

There is no direct mechanism to determine whether a detector station or sign has entered a shut-down mode to prevent damaging the batteries through a deep discharge. A shut-down condition may be inferred from a long period between data updates. If more than six hours elapses without an update for a battery voltage, it is believed the detector may have been off line. This occurred approximately 20 times.

Table 1 lists battery voltage alarm events that may have resulted in a detection zone being off-line. In all but two cases the alarms occurred during October–December, which are the months with the greatest cloud cover and weakest solar radiation. In the two cases that occurred during June, the batteries had been deeply discharged due to excessive activations on several occasions. These batteries were in the beacon assemblies which are smaller than the detector batteries. Both batteries were replaced in the fall of 2012.

Node 2 is also problematic as it is installed on the north side of the roadway and the tree line on the south side of the roadway can shade the panel during winter months. The combination of low sun angle, snow cover on the panel and tree shading resulted in the two Node 2 off-line times listed in the table.

Table 1 - Power System Alarms

Node	Alarm On Time	Alarm Off Time	Alarm Duration
NODE 1	2012-12-17 21:49:08 UTC	2012-12-19 15:16:06 UTC	1 day 17 hours
NODE 1	2012-12-17 02:25:14 UTC	2012-12-17 18:09:09 UTC	15 hours
NODE 1	2012-12-11 22:57:16 UTC	2012-12-12 17:33:45 UTC	18 hours
NODE 1	2012-11-05 03:37:06 UTC	2012-11-05 14:10:14 UTC	10 hours 33 minutes
NODE 2	2012-12-15 13:29:32 UTC	2012-12-19 15:41:07 UTC	4 days 2 hours
NODE 2	2012-12-11 00:40:59 UTC	2012-12-12 17:03:46 UTC	1 day 16 hours
NODE 5	2012-12-17 22:14:08 UTC	2012-12-19 16:21:07 UTC	1 day 18 hours
NODE 5	2012-12-11 22:52:16 UTC	2012-12-12 17:33:45 UTC	18 hours
NODE 5	2012-10-26 23:17:13 UTC	2012-10-27 13:12:14 UTC	13 hours
NODE 7	2012-12-18 00:44:08 UTC	2012-12-18 15:14:08 UTC	14 hours
NODE 7	2012-12-11 21:30:57 UTC	2012-12-12 16:18:46 UTC	18 hours
NODE 7	2012-12-11 04:28:16 UTC	2012-12-11 14:44:23 UTC	10 hours 16 minutes
NODE 8	2012-12-21 00:14:05 UTC	2012-12-21 15:04:15 UTC	14 hours
NODE 8	2012-12-19 20:41:06 UTC	2012-12-20 20:03:01 UTC	23 hours
NODE 8	2012-12-15 13:04:32 UTC	2012-12-19 15:06:06 UTC	4 days 2 hours
NODE 8	2012-12-13 01:19:15 UTC	2012-12-13 15:06:15 UTC	13 hours
NODE 8	2012-12-10 23:15:15 UTC	2012-12-12 17:48:45 UTC	1 day 18 hours
NODE 8	2012-06-12 02:35:25 UTC	2012-06-12 14:20:23 UTC	11 hours 44 minutes
NODE 9	2012-12-21 02:53:55 UTC	2012-12-21 14:39:15 UTC	11 hours 45 minutes
NODE 9	2012-12-19 22:26:07 UTC	2012-12-20 19:23:01 UTC	20 hours
NODE 9	2012-12-15 17:19:32 UTC	2012-12-18 16:19:09 UTC	2 days 22 hours
NODE 9	2012-12-15 16:49:32 UTC	2012-12-15 17:04:32 UTC	15 minutes
NODE 9	2012-06-12 05:45:22 UTC	2012-06-12 14:55:21 UTC	9 hours 10 minutes

Passive Infrared Detector

A Passive Infrared (PIR) detector was installed to evaluate its performance for detection where wildlife movements are constrained, such as along paths near bridges over waterways. To test the PIR detector, a conduit extension was attached to the detector station at Node 1. The detector evaluated in this case was an Optex Redwall SIP-404.

The detector was focused on the trail access on the north side of the roadway. By adjusting the detector angle and sensitivity, the detection area was constrained to an area roughly two feet wide and extending 20-25 feet from the detector across the trail. This small detection area prevented wind-blown vegetation or background vehicle movements from triggering the system. The detector was connected to a "standard" power system – identical to those used in other detection nodes. Detector outputs were connected to the communication device (Banner DX-80) input number three to verify that there would not be issues integrating the detector.

Because the beam-type and PIR detectors cover very different areas (by a factor of about 20), a direct count comparison is difficult. Using the beam detector as a baseline would make PIR detections seem artificially low. As a surrogate, the detection zone was repeatedly crossed to simulate wildlife presence. While the zone was occupied, the status of the input on the communications device was monitored and compared to the beam-detectors output. With 10 sample runs, both detectors detected the target.

The additional load on the power system depletes the detector station's batteries more rapidly. The power system appears to be more than capable of supporting either beam or PIR detectors independently, as power draws are similar for both devices. If both detection types are to be used together, moving from a 30-watt to a 40-watt solar panel is advised. The existing design can support a 40-watt panel on the detector structure, but larger panels should be evaluated for structural support needs before deployment.

Maintenance Information

Only four maintenance trips to the site were required during the course of the 12 month evaluation period. These four trips involved a total of 8 hours of on-site maintenance. Four additional maintenance trips were made to correct installation-related or software upgrade issues. These four trips were made on 12/28/2011, 3/7/2012, 3/14/2012, and 4/17/2012 and are unique to this first deployment of the latest revision of the system, and not expected in future deployments. These additional trips totaled 5.75 hours.

Remote monitoring and diagnostics were able to determine the cause of most alarms and resolve them without the need to travel to the system location. Software updates temporarily prevented the field hardware from connecting to the remote database, but even in these cases the system continued to function with detection and beacons operating as intended.

System maintenance consisted of maintaining the vegetation in the area and monitoring the system for unusual operation through automatic alarms and conducting any service as needed. As of December 2012, the system required 13.75 hours of on-site component maintenance (other than routine mowing to keep vegetation from triggering false activations). Table 2 provides detailed system maintenance information for any issue that required on-site intervention to correct. One staff person was sufficient to complete these on-site maintenance tasks.

Individual detectors or signs had brief off-line events, although directly measuring this is difficult as documented in the "Power System" section. Detectors all returned to normal functioning automatically if they experienced any off-line time.

Table 2 - Maintenance Action Log

Report date	Trouble Report	Service Date	Person-Hours on site	Action Taken	Status
12/20/2011	Node 2 panel voltage shows low in monitoring software	12/28/2011	0.5	None, panel is shaded by trees on the south side of the roadway	Completed
2/21/2012	Overnight stuck high on Zone1. Self Correcting, probably due to heavy snowfall	-	-	-	No Action Needed
2/29/2012	Several zones stuck high overnight during freezing rain. Appears self-correcting, suggests ice formation on detector surface. Zones 6,7 appeared to "flutter" on/off - generated ~900 activation calls. Within 12 hours, all but zone 7 returned to normal state.	-	-	Monitor to make sure all zones return to normal operation.	No Action Needed
2/29/2012	Excessive condensation noted during Fall check-out inside control station cabinet.	4/17/2012	0.5	Seal conduit entries with duct seal putty during spring check-out	Completed
2/29/2012	Alignment of EB beacon restricts viewing distance	4/17/2012	0.5	Rotate beacon head toward roadway	Completed
3/7/2012	System not reporting data to server since 3/2	3/7/2012	-	Set-Point, Inc. loaded an upgraded kernel on 3/2 that caused the issue. Revised kernel loaded on 3/7. No data lost, system functioned during issue.	No Action Needed
3/14/2012	System not functioning from 3/9 due to software load error	3/14/2012	1.5	Examine system for damage- none found. Reset gateway I/O node. System began functioning normally.	Completed
3/19/2012	System generated multiple battery low errors at approximately 7:00 PM	3/20/2012	-	Alarms traced to ~90 second disruption in communications during heavy thunderstorm. System functioned normally without intervention	No Action Needed
12/20/2011	Improper voltages displayed for Node 3	12/28/2011	0.5	Voltages confirmed proper at device and on voltage divider. But when connected to Node I/O, voltages are doubled, exceeding 10 V limit. Second visit required to verify all wiring.	
	cont'd	4/17/2012	1	Unable to get proper voltage readings on Node - likely to be a damaged/defective part. Will consult with Banner	
	cont'd	5/1/2012	1	Poor connection Identified on node interface/power cable. Reseating connection eliminated problem	Repaired
4/17/2012	Attachment nut missing from EB sign shield	4/17/2012	0.25	Install new nut and lock washer; check all bolts for tightness	Repaired
4/17/2012	Water found inside sign equipment cabinets	4/17/2012	0.25	Drain water and install duct seal around conduit attachment. Add 1/16" weep hole to bottom of cabinet on next visit	Completed
4/17/2012	Zones 1 & 2 inputs transposed	4/17/2012	0.25	Correct wiring to connect detectors to proper inputs on I/O node	Repaired
4/30/2012	Zones 9 & 10 have abnormally low counts for last several weeks.	5/1/2012	0.5	Positive (+) lead from power supply to power distribution block disconnected. Possible vandalism. Wire reconnected and zones functioned normally.	Repaired
6/10/2012	Excessive activations on several zones, particularly Zones 9&10. Examination of the sight revealed tall grass between detectors	6/12/2012	4	Trimmed grass using a weed trimmer	Completed
10/22/2012	System not logging detections for several zones	10/26/2012	1	Communications gateway indicated Error Code 53 (connection error). Reset gateway resolved issues	Repaired
10/30/2012	Excessive low voltage indications on Nodes 1,5,8,9	11/5/2012	2	Replaced batteries	Repaired
	TOTAL MAINTENANCE PERSON-HOURS		**13.75**		

Summary

The Wildlife Detection and Active Warning System installed in Dayton, Minnesota operates as intended, although the numbers of detections is higher than expected. Maintenance requirements have been minimal (approximately 1.4 person-hours per month on average), and the only failures have been depleted batteries. Repairs consisted of replacing the batteries, which totaled $321.74 in replacement parts.

The remote monitoring system has been reliable and has minimized the need for on-site work, minimizing staff costs. The ability to re-enable disqualified detectors and verify power system status has been particularly valuable.

The PIR appears to be a viable method of detection in cases where a pair (transmit/receive) of detectors is undesirable and wildlife movements are constrained. This detection approach is compatible with the existing power and communications systems.

Future modifications to operation control software may minimize the number of alarm notifications sent and identify only critical conditions rather than the more aggressive notification scheme currently in use. Assessment of solar power availability may recommend the use of larger (40 watt) panels in some cases.